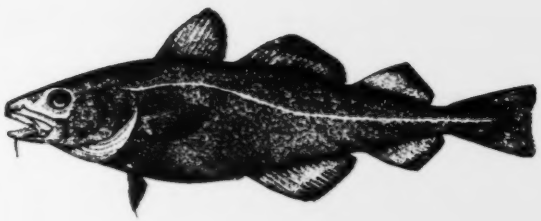
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Quebec Region
Canadian Science Advisory Secretariat
Science Advisory Report 2010/011

ASSESSMENT OF THE COD STOCK IN THE NORTHERN GULF OF ST. LAWRENCE (3Pn,4RS) IN 2009



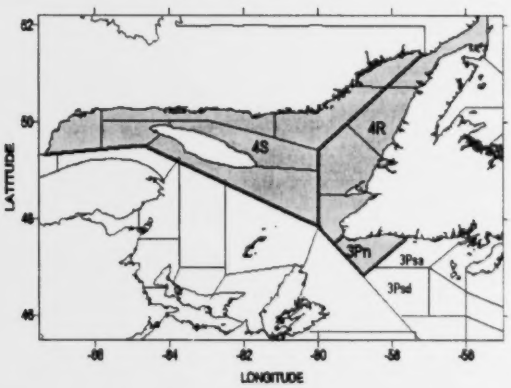


Figure 1. Cod stock management area in the Northern Gulf of St. Lawrence (3Pn,4RS). For reference, fishing areas 3Psa and 3Psd are also indicated.

Context

Landings during 1974 to 1993 were from a mixture of fixed and mobile gears by Canadian fleets, as well as from foreign fleets using mobile gear. Since the reopening of the fishery in 1997, all landings are from fixed gear fisheries (handlines, longlines and gillnets). The first TAC was introduced in 1977 and was set at 55,000 t. The fishery management followed the calendar year until 1998, after which the management year was May 15 of the current year to May 14 of the following year.

The assessment of the cod stock in the Northern Gulf (3Pn,4RS) (Figure 1) is conducted annually using commercial fishery data and abundance indices from sentinel fisheries and a DFO research survey. Resource status is primarily estimated using a population model, but results of tagging programs are also used to estimate exploitation rates. Advice is also provided in the context of the precautionary approach. The resource is managed mainly by annual TACs (total allowable catches) and a series of other management measures (closing areas during the spawning period, presence of observers, dockside monitoring, minimal size of catches, controlling by-catches, etc).

The present assessment is the result of a request for science advice from the Fisheries and Aquaculture Management Branch. The main objectives of the review were to evaluate the status of the stock and to provide scientific advice concerning conservation outcomes related to various fishery management options.

Canada

SUMMARY

- The 2009/2010 total allowable catch (TAC) was 7,000 t. Preliminary landings available as of January 2010 totalled 4,686 t Landings from the 2009 recreational fishery were not available at the time of the assessment.
- Catch rates from the commercial logbooks and the telephone survey conducted with fishermen show a decline since 2006.
- Sentinel catch rates in weight for longlines and gillnets peaked in 2006. Both have declined over the past three years by 54% and are slightly below the 1995 to 2008 average.
- The catch rate for the DFO research vessel (RV) survey and the mobile gear sentinel survey remain low and show no trend since 1997.
- Natural mortality estimated by the sequential population analysis (SPA) over the last years has increased. Possible causes are an increase in seal consumption and an increase of unaccounted mortality such as discards and the recreational fishery.
- The exploitation rate estimated by the SPA has increased since 2004 to reach 29% in 2009. This is confirmed by tagging analysis that indicates exploitation rates of 26% in 2008 and 21% in 2009.
- The abundance of the spawning stock in 2009 and projected to 2010 is well below the limit reference point. The stock has remained in the critical zone for many years.
- According to the various analysis presented (variations of mature numbers according to the landings, analysis of life tables based on fecundity), it is obvious that landings above 4,000 t will not allow the stock to increase.
- In order to promote stock rebuilding, catches in 2010 should be less than 4,000 t

BACKGROUND

Species Biology

Northern Gulf of St. Lawrence cod (NAFO Divisions 3Pn and 4RS) undertake an extensive annual migration. In winter, they are found off southwestern (3Pn) and southern Newfoundland (3Ps) at depths of more than 366 m (200 fathoms). In April and May, they migrate towards the Port au Port Peninsula, on the west coast of Newfoundland (Division 4R), where spawning begins. During the summer, fish continue their migration and disperse in the coastal zones, along the West coast of Newfoundland (Division 4R) and towards Quebec's Middle and Lower North Shore (Division 4S). This migration to the coast is associated with warmer water and the presence of capelin (*Mallotus villosus*). Based on the results from numerous tagging experiments, this stock is generally isolated from adjacent stocks. There can be occasional mixing in the northwest part of the Gulf, (with 4TVn cod), in the Strait of Belle Isle, (with 2J,3KL cod). However, mixing in the Burgeo Bank area (with 3Ps cod) is considered to occur every year during winter. A study determined that 75% of cod present on the Burgeo Bank (3Psa and 3Psd) in winter might come from the northern Gulf.

Growth, condition, size and age at sexual maturity decreased in the mid-1980s and in the early 1990s, periods when oceanographic conditions were unfavourably cold. These changes had a negative impact on fecundity and the reproductive rate of the population. In addition, the natural mortality rate (*M*) has increased. The reasons for this increase are unclear but appear, in some years, to be related to poor fish condition, particularly after spawning. Growth and reproductive characteristics improved after the mid-1990s to the levels of the early 1980s. However the mean length-at-age for older fish and age and size at maturity remained at lower levels than in the 1980s. Cod start maturing at age 4 and size at 50 % maturity is currently about 45 cm (age 5).

Ecosystem status

In the northern Gulf of St. Lawrence, 2008 was a cold year with water temperature in the cold intermediate layer similar to 2003. Zooplankton abundance in the Gulf was above average in 2007. The trends in the main species caught in the northern Gulf of St. Lawrence DFO research vessel (RV) survey during 1990 to 2008 indicate that turbot, halibut, and shrimp increased during the last 10 years and are currently at relatively high abundance levels. Redfish remains at low abundance following intensive fishing in the 1980s and early 1990s. Pelagic species (herring and capelin) abundance seems relatively healthy although their assessments are uncertain. Simulations using abundance data from RV surveys and diet data from various sources suggest that intensive fishing during the 1980s & early 1990s removed most of the large piscivorous fish trophic level (i.e., cod and redfish), which has left marine mammals as the dominant top predators in the northern Gulf during the 2000s.

Fishery

Cod landings in the northern Gulf of St. Lawrence exceeded 100,000 tonnes in 1983 (Figure 2). Landings declined continuously until 1993. During the decline, vessels using mobile gear generally caught their allocation, whereas those using fixed gear failed to do so. The fishery was under moratorium from 1994 to 1996. It reopened in 1997 and catches and TACs have varied between 3,000 to 7,500 tonnes since (Table 1), except in 2003 when the fishery was closed again. Currently, it is the only Atlantic coast cod stock where the directed fishery is only conducted with fixed gears (longlines, gillnets and hand lines). In 2002, a new management zone was established in 4R off St. George's Bay to protect the spawning stock. In this area, the groundfish fishery is prohibited between April 1st and June 15th.

The 2009 total directed cod fishery allocation was not caught. No data from the recreational catch in 2009 was available at the time of the assessment.

Table 1. Cod landings and TACs (in thousands of tonnes) in divisions 3Pn,4RS

Year	*1977-1993*	*1994-1996*	*1997*	*1998*	*1999-2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
TAC	*70.4*[1]	*0*[1]	*6*	*3*	*7.1*[1]	*0*	*3.5*	*5*	*6*	*7*	*7*	*7*
Landings	*70.2*[1]	*0.3*[1]	*4.8*	*3.3*	*6.8*[1,3]	*0.4*	*3.3*	*4.5*	*5.7*[4]	*6.5*	*6.2*[2,5]	*4.7*[2,6]

[1] *Average*
[2] *Preliminary data*
[3] *Includes landings from the recreational fishery, 253 t in 2001 and 34 t in 2002*
[4] *Includes 75 t from the recreational fishery*
[5] *Includes 67 t from the recreational fishery*
[6] *No data from the recreational fishery available*

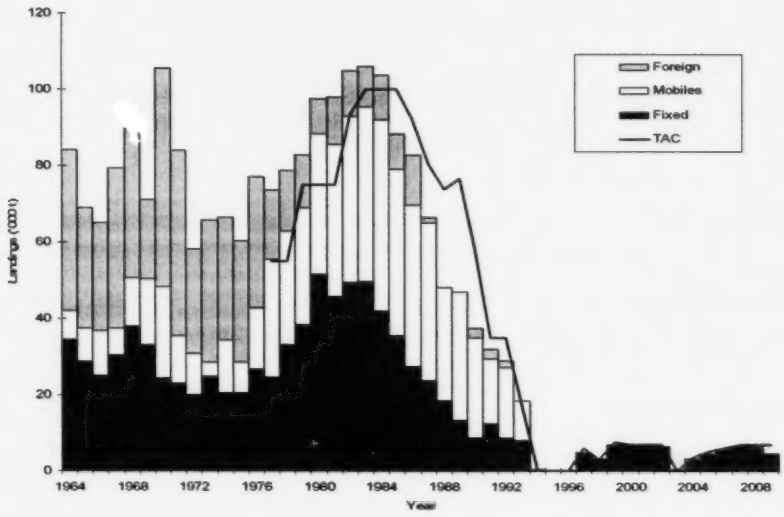


Figure 2. Annual landings and total allowable catches (TACs) for the management years.

Logbook data

Logbooks have been mandatory since 1997 for commercial fishing boats under 35 feet directing on cod in NAFO Divisions 3Pn and 4R, and for boats under 45 feet since 1999 in NAFO Division 4S. Those logbooks are analyzed to assess the performance of fixed gear commercial fleets. Landings from these fleets represent around 70 % of the annual landings in the cod directed fishery. For all area combined, gillnet and longline commercial catch rates were fairly stable until 2002. Catch rates have increased after the 2003 moratorium for both gear types, and the maximum value was observed in 2004 for gillnets and in 2006 for longlines. Those catch rates have decreased after 2006 and in 2009 they were comparable to values observed in the 1997 to 2002 period (Figure 3). The trends are quite similar in each NAFO Division and the decrease in catch rates from 2006 to 2009 has been observed in 3Pn, 4R, and 4S.

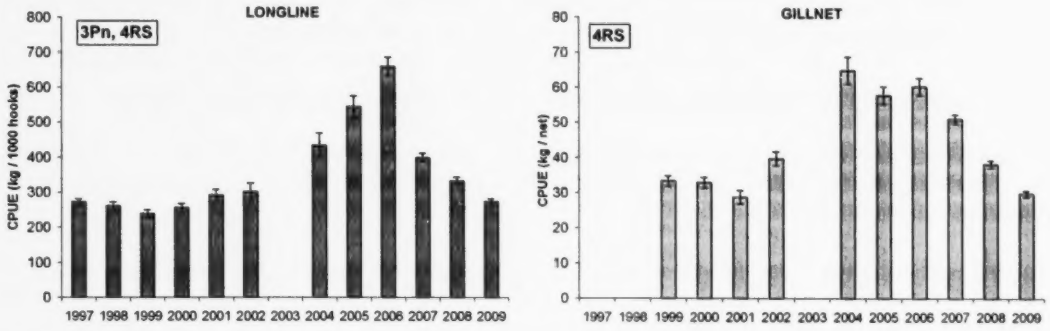


Figure 3. 3Pn,4RS cod commercial logbook catch per unit of effort (CPUE) for vessels less than 45 feet (1997-2009). Error bars are ± 95% confidence intervals.

ASSESSMENT

Sources of information

Stock status was updated using data from commercial landings and abundances indices based on fixed gears sentinel fishery (1995 to 2009), a sentinel otter trawl survey (1995 to 2009), and an annual DFO research vessel (RV) survey (1990 to 2009). Catch rate data from logbooks for vessels less than 35 feet in 3Pn,4R (1997 to 2009) and less than 45 feet in 4S (1999 to 2009) were also examined. Annual exploitation rates were estimated from tagging experiments conducted in different regions of 3Pn,4RS during 1997 to 2009.

Biological Data

A substantial decrease in the age and length at 50% maturity was observed in 2009. Length at 50% maturity decreased from 44.6 cm in 2008 to 39.3 cm in 2009. Age at 50% maturity declined by almost 1 year from an age of 5 in 2008 to an age of 4.2 in 2009.

Fecundity at size and age has dropped significantly between the early and mid 1990s. A gradual increase in fecundity at size has occurred since the mid 1990s, and current levels are comparable to those in the mid 1980s. However, some decline in fecundity at age was observed in 2009 for age 7 and less due to lower sizes at those ages in the spring of 2009.

Cod condition information from the sentinel fisheries program indicates an annual cycle. Condition is maximum in the fall and minimum in the spring. Energy reserves accumulated in late fall are critical for cod and must be sufficient for fish to survive winter and the spawning period in the spring. Seasonal Fulton condition cycle in 2009 is similar to the 1998 to 2008 average.

Stock trends

The sentinel fixed- and mobile-gear fishery programs were implemented in 1994 in order to monitor the abundance of the stock and develop a partnership between the industry and the Department of Fisheries and Oceans. The sentinel fisheries are conducted within a well defined

protocol and provide indices of resource abundance and other data. All catches that are made within the framework of the sentinel fisheries are accounted for in the TAC.

Abundance indices based on catch rates from fixed gear sentinel fisheries

The fixed gear sentinel program provide abundance indices derived from gillnets and longlines. Catch per unit effort (CPUE) data are standardized to provide an index of annual trends of cod abundance since 1995.

The gillnet abundance index for 4R and 4S showed variations without much trend between 1995 and 2001 (Figure 4), it doubled from 2001 to 2003 with a maximum in 2006. The longline abundance index in 3Pn,4RS showed an increase between 1995 and 2001, followed by a decrease in 2002 and 2003. The longline index increased from 2004 to a maximum in 2006. Sentinel longline and gillnet abundance indices decreased from 2006 to 2009 and are now below the 1995 - 2008 average.

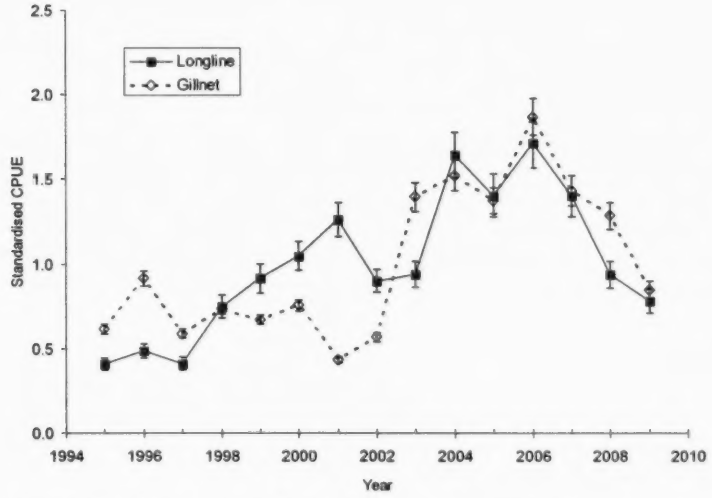


Figure 4. Standardized catch rates from the fixed gear sentinel program.

Abundance index based on the July mobile sentinel survey

Nine trawlers participate in the July sentinel mobile survey. They use the same gear, a Star Balloon 300. A restrictor cable is used to maintain a constant and comparable trawl opening during fishing operations.

This survey follows a depth-stratified random sampling protocol similar to that used in the DFO RV survey. In July 2003, three new shallow strata with depths ranging between 10 to 20 fathoms were added in the 4R Division. The information from these additional strata has been included for the first time in last year's assessment. To do so, the survey index was divided into two periods. A 1995 to 2002 index based on the sampling of strata of 20 fathoms and more, and a 2003 to 2009 index including all strata i.e. 10 fathoms and more.

The abundance index increased from 1995 to 2001 and then decreased in 2002 (Figure 5). The new abundance index including all strata varied little during 2003-2008 and shows a slight increase in 2009. The 2009 value is above the 2003-2008 average.

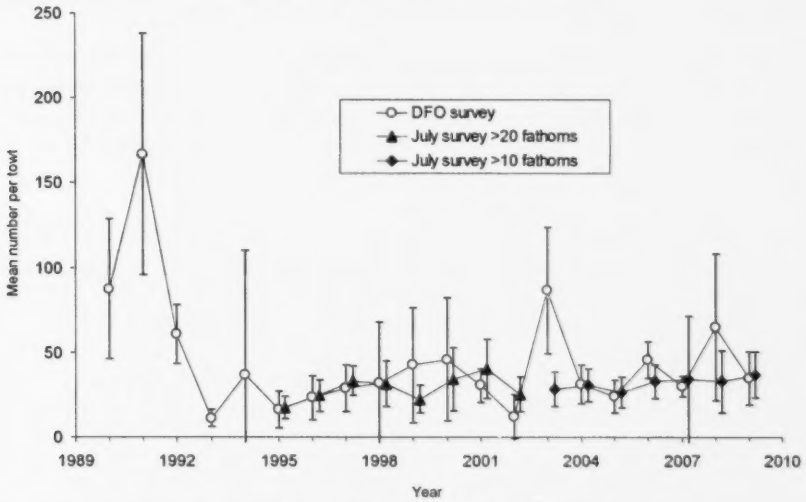


Figure 5. Mean number per tow for the August DFO RV and the July sentinel mobile surveys.

Abundance index based on the DFO RV survey

The DFO trawl survey began in 1990 on the CCGS *Alfred Needler*. Since 2004, this survey has been carried out on the CCGS *Teleost*. Inter-calibrations were conducted in 2004 and 2005 in order to account for changes in vessel, gear (URI trawl to Campelen trawl) and tow duration (from 24 to 15 minutes) (Bourdages et al. 2007). The CCGS *Teleost* survey is about 10 times more efficient at catching small cod and twice as efficient for larger cod than the CCGS *Alfred Needler* survey. To account for these differences, a conversion factor based on length is used to adjust historic catches from the CCGS *Alfred Needler* to make them comparable to those of the CCGS *Teleost* survey.

The results indicate a sharp decline in cod abundance during 1991 to 1993 followed by an increase until 2000. The timing of the increase corresponded to the period of the first moratorium during 1994 to 1996 (Figure 5). Abundance then fluctuated with little trend from 2001 to 2009. An abnormal low value occurred in 2002 and a high value occurred in 2003. These year effects were seen for other species in the surveys.

Current Status

The population model used in this assessment to integrate information on stock status was sequential population analysis (SPA).

Natural mortality (*M*)

As recommended at the 2007 workshop on natural mortality for both cod stocks in the Gulf of St. Lawrence (DFO, 2007), natural mortality values (*M*) were fixed for earlier period and estimated in the SPA for the recent time. Values of *M* for all ages were fixed to 0.2 prior to 1986 and to 0.4 from 1986 to 1996. They were estimated for three periods: 1997 to 2000 (*M* = 0.181

± 0.041 standard error) and 2001 to 2004 (M = 0.216 ± 0.031 standard error) and 2005 to 2009 (M = 0.383 ± 0.036 standard error).

Total population estimates

SPA provides estimates of population abundance by year and age taking into account natural mortality (M) and fishing mortality (F). The analysis is based on reported catches at age for the commercial fishery. It is calibrated using sentinel longline (ages 3 to 13) and gillnet (ages 4 to 13) indices, mobile gear sentinel indices (ages 2 to 11), and indices from the DFO RV survey (ages 2 to 11).

According to the SPA, total abundance (ages 3+) declined from 559 million in 1980 to 31 million in 1994, then slowly increasing to attain 58 million individuals in 2010. The number of spawners estimated from the population numbers and maturity ogives decreased from 200 million in 1983 to 7 million in 1994. It has increased to 19 million individuals in 2010.

The exploitation rate of 7 to 9 year-old individuals, estimated by the population model, was high (around 30%) from 1999 to 2002. Exploitation rate was very low in 2003 due to the moratorium (Figure 6). The exploitation rate associated with the 2009 fishery totalling 4,686 tonnes was 29%.

Since 1995, the Sentinel Fisheries Program has tagged more than 77,000 cod. The program includes components aimed at assessing initial mortalities caused by tagging (with the use of traps); the loss of tags (by double tagging); and the tag reporting rate (by using high-reward tags and a telephone survey). So far, more than 7,000 tags have been recovered. The tagging program is independent from the population model; therefore, it is a useful and complementary method to estimate annual exploitation rates. Exploitation rate from both sources show similar trends until 2007 (Figure 6). The 2009 exploitation rate from tagging is preliminary and may increase lightly if additional tags are reported in 2010, as has occurred in the past.

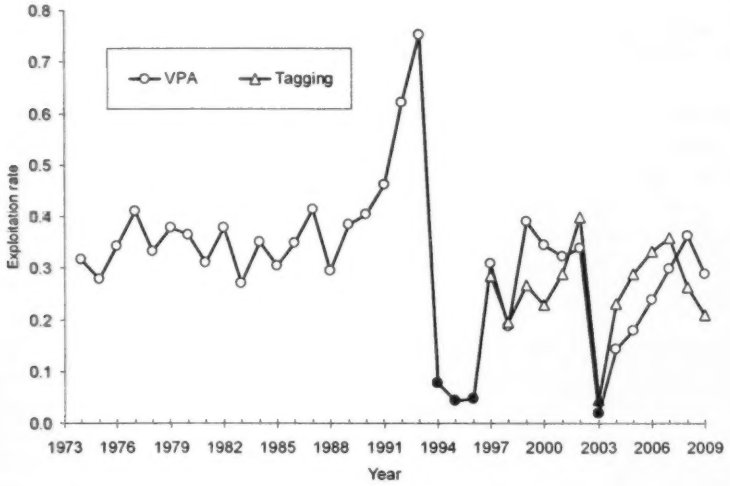


Figure 6. Exploitation rates of 7 to 9 year-old cod estimated by the population model and by tagging experiments for fish 40 to 80 cm long. Full circles represent the moratorium years.

The 2004 year class was previously estimated to be relatively abundant at age 2 in 2006. However, subsequent estimates from surveys have resulted in a downward revision. This year-class is now estimated to be of similar abundance to the 1993 year-class (Figure 8). This age-class will contribute to the 2010 fishery at 6 years old.

The 2006 year-class at age 2 in 2008 was also previously estimated to be relatively abundant at age 2 in 2008. However, subsequent estimates from surveys have resulted in a downward revision. This year-class is estimated to be of similar abundance to the 1993 year-class (Figure 8) and will not contribute to the 2010 fishery.

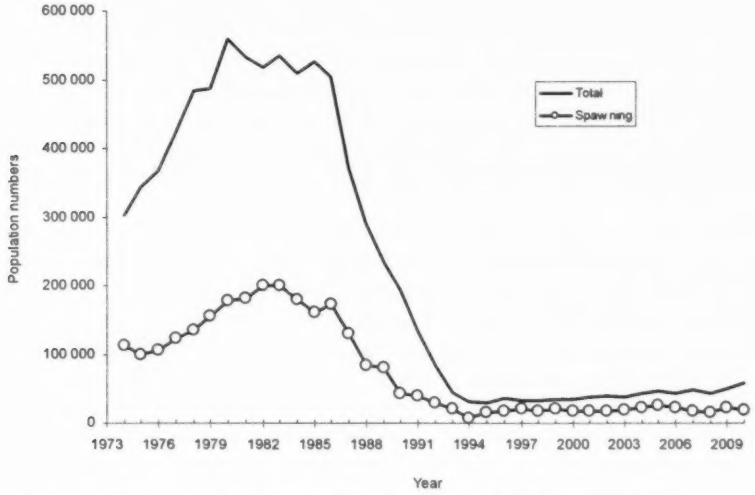


Figure 7. Estimated population numbers (ages 3 and older) and mature population.

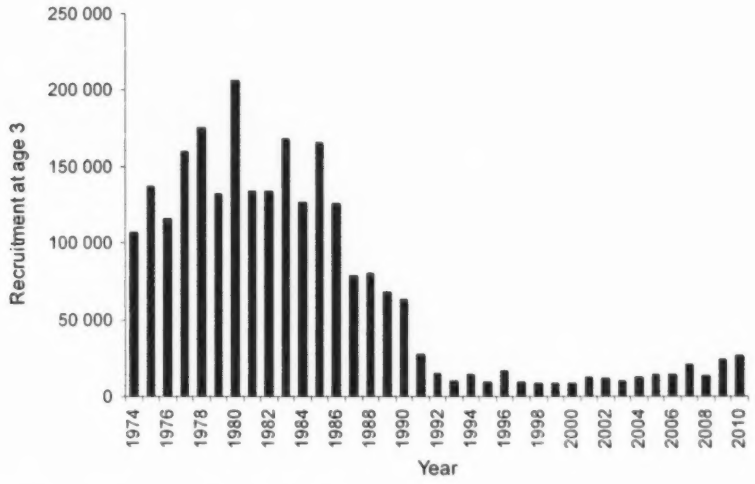


Figure 8. Estimated number of 3 year-old recruits.

Total production of eggs for the stock, the probability of survival between hatching and recruitment at age 3 and the potential rate of population increase were estimated. Based on

values of natural mortality, estimates of the rate of population growth (r) in the 1986 to 1995 period using matrix population models (Leslie matrices) were either low or negative indicating that over that period the biomass of the stock would have decreased even without fishing. Following that period, maximum rate of population growth was estimated to be in the range of 5 to 15% per year without fishing. However, since 2005, this rate varied between -3 and 8% with a mean value of 4.7% per year. Taking into account fishing mortality, maximum rate of population growth fluctuated between -14% and 11% since 1998 with negative values for all years since 2006.

Sources of Uncertainty

Northern Gulf cod are known to migrate to 3Ps in winter (Méthot *et al.* 2005). Since 1999, a portion of Burgeo Bank (3Psd, Figure 1) has been closed to the cod fishery from November 15th to April 15th to prevent northern Gulf cod from being captured during the winter fishery in the western part of 3Ps. This sector would correspond to a fraction of the mixing area between the 3Pn,4RS stock and the 3Ps stock. It is possible that historical estimates of catches from the stock may have been affected by this mixing and as such constitutes a source of uncertainty.

The use of the fixed gear sentinel fishery activities as an abundance index is based on the assumption that the resource's abundance is proportional to the catch rate. However, this assumption can be incorrect if the fishing gear becomes saturated, (i.e. if the gear reaches a catch level that doesn't allow for anymore catches). This aspect of fishing gear saturation is evaluated annually for the activities of the longline sentinel fishery program. Both catch rates and saturation have decreased in sentinel longlines from 2006 to 2009. In addition, these fixed gear sentinel surveys cover a small part of the stock area and are sensitive to changes in the spatial distribution of the stock. They may reflect local stock densities more than overall stock size. The saturation results in an underestimate of the CPUE at high densities or an underestimation of stock growth or decline as seen presently.

ADDITIONAL STAKEHOLDER PERSPECTIVES

For the thirteenth consecutive year (no survey in 2004 due to the 2003 moratorium), the Lower North Shore Fishermen's Associations of Quebec and the Fish, Food, and Allied Workers Union of Newfoundland and Labrador have conducted telephone surveys of fixed gear cod license holders based on a random sampling design. These organizations are the sponsors of the 4S and 4R, 3Pn, Sentinel Program since its inception in 1994. The objective of the survey was to review various aspects of the fishery including biological information and abundance via trends in catch rates.

Respondents in all three areas noted a significant change in the overall size of the fish over the past two years. As a percentage of the catch, 2009 has indicated more smaller fish than anytime within the last decade. Respondents did not note any change in fish condition and as in recent years, their observations were extremely positive. With respect to spring / summer migration, the majority of the respondents indicated minimal change from 2008, however, in 2009 a higher percentage of 3Pn respondents noted an earlier migration in the spring. There was little or no change in fishing depth from 2008.

Interviewed harvesters in all areas noted a decrease in catch rates in 2009 compared to 2008 (Figure 9). Harvesters also noted however that market conditions was certainly a contributing factor to lower catch rates.

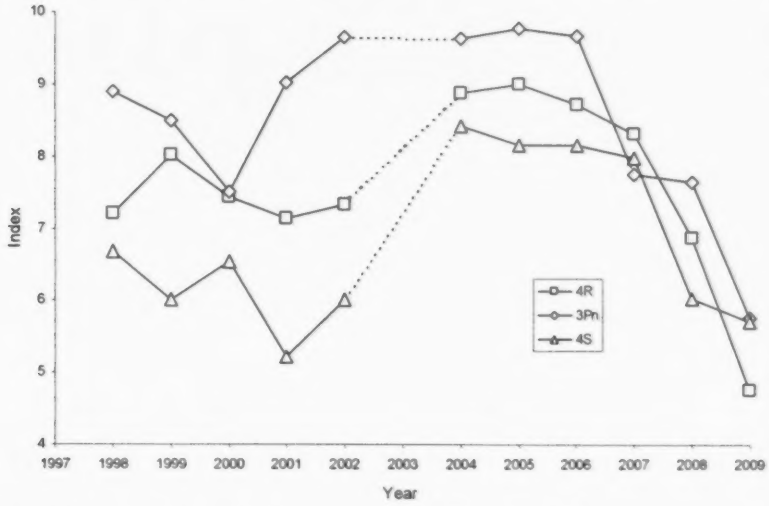


Figure 9. Performance index from a telephone survey with fixed gear fishermen.

CONCLUSIONS AND ADVICE

Based on current productivity, the exploitation rates that have been observed in the period 2000 to 2009 have been too high (except for 2003 which was under moratorium) to allow for any significant rebuilding of this stock.

Landings since 1994 have affected the annual changes in mature numbers (Figure 10). Based on the SPA, mature numbers increased from 6 to 21% for each moratorium year (1995 to 1996 as well as 2003) for an average exploitation rate of 3%. Landings exceeding 4,000 tonnes in 1997, between 1999 and 2002, and between 2005 to 2009 resulted in an average 4% drop in mature numbers with exploitation rates reaching 29 %. This value is about twice the old target exploitation rate $F_{0.1}$ which corresponds to an exploitation rate of about 17%. This target was in place in the 80's while the mature numbers were ten times larger than its current size. The rapid declines in the abundance indices observed over the last three years are thus very coherent with past advice. Such exploitation levels are not sustainable at present productivity, and are inconsistent with a rebuilding strategy.

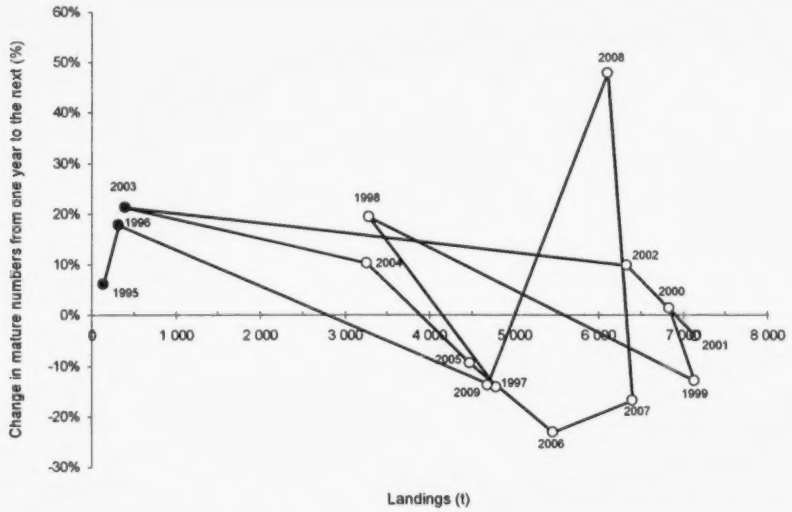


Figure 10. Relation between landings since 1995 and mature numbers. Full circles represent the moratorium years.

SOURCES OF INFORMATION

Bourdages, H., L. Savard, D. Archambault and S. Valois. 2007. Results fom the August 2004 and 2005 comparative fishing experiments in the northern Gulf of St. Lawrence between the CCGS *Alfred Needler* and the CCGS *Teleost*. Canadian Technical Report of Fisheries and Aquatic Sciences. 2750. 57 p.

DFO, 2006. A harvest strategy compliant with the precautionary approach. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/023.

DFO, 2007. Accounting for changes in natural mortality in Gulf of St Lawrence cod stocks. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/002.

Fréchet, A., J. Gauthier, P. Schwab, Y. Lambert, A Le Bris, C. Tournois, M. Way and F. Collier. 2007. The status of cod in the Northern Gulf of St. Lawrence (3Pn,4RS) in 2008. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/090. 108 p.

Le Bris A., A. Fréchet ,J.-C. Brêthes. 2009. Estimation of the exploitation rate of the northern Gulf of St. Lawrence (3Pn,4RS) Atlantic Cod (*Gadus morhua*) stock, based on tagging data. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/012. v + 35p.

Méthot, R., M. Castonguay, Y. Lambert, C. Audet, and S.E. Campana. 2005. Spatio-temporal distribution of spawning and stock mixing of Atlantic cod from the northern Gulf of St. Lawrence and southern Newfoundland stocks on Burgeo Bank as revealed by maturity and trace elements of otoliths. J. Northw. Atl. Fish. Sci. 36 : 31-42.

Yvelin, J.-F., A. Fréchet and J.-C. Brêthes. 2005. Migratory routes and stock structure of cod from the Northern Gulf of St. Lawrence (3Pn,4RS). DFO Can. Sci. Advis. Sec. Res. Doc. 2005/055 56p.

FOR MORE INFORMATION

Contact : Alain Fréchet
Maurice Lamontagne Institute
850, route de la Mer
P.O. Box 1000
Mont-Joli (Quebec)
G5H 3Z4
Tel: (418) 775-0628
Fax: (418) 775-0679
E-Mail: Alain.Frechet@dfo-mpo.gc.ca
Internet address: http://ogsl.ca/en/sentinel/context.html

This report is available from the:

Center for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
P.O. Box 1000, Mont-Joli
Quebec (Canada)
G5H 3Z4

Telephone: (418) 775-0825
Fax: (418) 775-0679
E-Mail: Bras@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)
© Her Majesty the Queen in Right of Canada, 2010

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION:

DFO. 2010. Assessment of cod stock in the northern Gulf of St. Lawrence (3Pn,4RS) in 2009. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/011.